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Practical work in primary science education: using a scoping review and educator survey to create a new framework for prioritising purposeful use

Sarah Earle [a], Stuart Read [a], Lynne Bianchi [b] and Julie Jordan [b]

[a]School of Education, Bath Spa University, Bath, UK; [b]SEERIH, The University of Manchester, Manchester, UK

ABSTRACT

Practical work is seen as a fundamental part of science education, but its purpose in primary (age 5–11 in the UK) is not always clear. A new definition for practical work raises the profile of multi-modal communication during "hands-on", "minds-on" science learning experiences. This scoping review of academic and grey literature identified ten possible purposes for practical work within 54 included documents. These ten purposes were applied to the reality of educators' experiences through a UK-wide survey ($n = 231$), with participants asked to describe what they saw the purpose of practical work to be, before being asked to rate the relative importance of the ten extracted from the literature. Participants identified all purposes as important, but some as less likely to be enacted in the classroom. A "Purposes of Practical Work in Primary Science Framework" is presented to support the prioritisation of objectives for the focus of individual practical work activities.

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Introduction

Practical work is a defining feature of science education, something that makes science a unique subject in schools (Gatsby 2017). Activities are "practical" when children are "hands-on", manipulating and observing real objects and materials (Abrahams and Millar 2008, 1945). Practical work in secondary science is a well-researched area, but the primary perspective has received less attention. Definitions and guidance based on research in secondary school laboratories may not be specific or relevant enough to support the primary context, where young children build foundational understanding in classroom and outdoor learning situations, with often the same class teacher across all subjects and more everyday materials rather than specialist equipment. Practical work in primary science can be seen as an additional burden for teachers who may lack confidence in science and under an accountability regime that favours the subjects of English and mathematics (Markwick and Reiss 2023). Thus, practical work needs a clear rationale for it to be enacted as an essential feature of a primary science lesson. This article aims to provide clarity regarding the purposes for practical work in the primary context.

CONTACT Sarah Earle s.earle@bathspa.ac.uk Bath Spa University, UK

Rationale

There was no clear consensus for the purpose of practical work in primary science education identified within the forthcoming literature reviewed in this study. Many authors and curricula documents provided a brief list of purposes, but these all included different elements and often referred to secondary school laboratory work. For example:

> practical work motivates students, teaches them laboratory skills, improves their learning of science, gives them insight into scientific methods and develops scientific reasoning, such as objectivity and open-mindedness (Vinko, Delaney, and Devetak 2020, 11)

> develop understanding of the nature, processes and methods of science through different types of science enquiries that help them to answer scientific questions about the world around them (English National Curriculum, DfE 2013, aim)

The lack of clarity and consensus led to the following research question (RQ) for this study:

RQ: How is purposeful practical work understood in primary school science in the UK?

In order to answer this question, we completed a scoping review of international and grey literature, together with collecting the perspectives of primary science educators across the UK via a nationwide survey, to consider how purposeful practical work is understood from a uniquely primary perspective. We used the scoping review to build the theoretical framework for the study and to identify possible purposes, hence we will explain the methodology for this early in the article, before presenting findings from the literature and then the survey.

Defining practical work in primary science

Before moving on to the "purposes" focus for this article, we need to explicitly define what we mean by "practical work" for the primary school context. Previous definitions of practical work have largely been based more within the secondary context. Definitions usually include direct interaction with "real objects" (Abrahams and Millar 2008; SCORE 2013), but also often mention experiments in a laboratory (Abrahams et al. 2014; Wei et al. 2022). Primary schools in the UK do not have such specialist facilities, with science taking place within the standard classroom or outdoors. To emphasise the importance of the physical experience for the primary phase, we utilise the following primary-specific definition:

> Children observe, manipulate, communicate and connect their science thinking through sensory learning experiences with physical objects and phenomena. (Earle et al. 2025, 10)

This definition refers to "sensory experiences" as more inclusive terminology than "hands-on", that recognises the embodied nature of young children's learning experiences, interacting with materials to build foundational concepts (Tang et al. 2022).

Context

This paper is embedded within the context of the four nations of the United Kingdom (UK). Each nation (England, Scotland, Wales and Northern Ireland) has their own national curriculum, but the structures of education are similar, with children beginning primary school at 4–5 years until 11–12 years. Children are usually taught in classes of 25–30, by a class teacher who teaches all of the subjects. The level of detail within the curricula varies, as well as the subject emphasis, for example, with science explicitly linked with technology in Wales, and history and geography in Northern Ireland's "World Around Us" strand.

The aim of a Nuffield Foundation-funded "Purposeful Practical Work" project (Earle et al. 2025), was to make the purpose of primary science practical work more explicit and coherent. We sought to enable and empower primary teachers to make more informed pedagogical decisions to select the most appropriate practical activities for supporting children's science learning. This responds to sector concerns that children are engaged in prescriptive practical work that lacks purpose, and that they often experience "fun" science activities that fail to deepen or develop new learning (Bianchi, Whittaker, and Poole 2021).

One outcome of the project was a new framework to support the prioritisation of purposes for practical work (Figure 1). The framework contains a range of possible purposes for practical work, but proposes prioritisation of the core purposes of developing the practices and/or concepts of science as the most important reason for selecting and carrying out such activities in the primary setting. This framework was built as an outcome from this study, with different purposes collated from a scoping literature review (Phase 1) and then applied to practice in an educator survey (Phase 2). The new framework is presented at the outset, to support the reader see how the study informed its

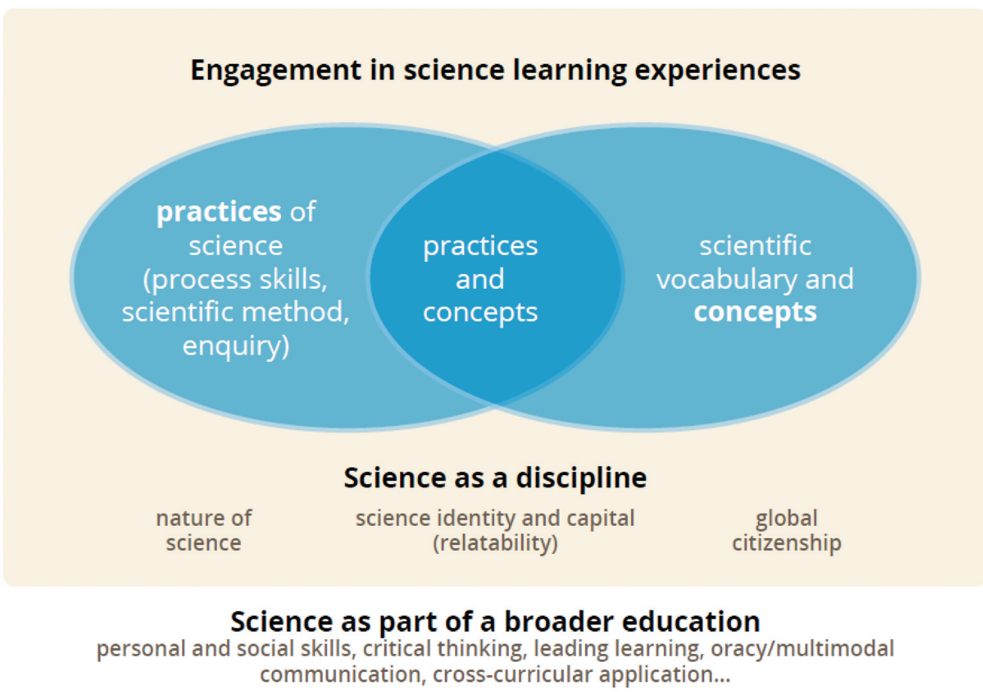

Figure 1. Purposes of practical work in primary science framework: supporting the prioritising of purpose, from initial engagement, to core lesson purposes of developing the practices and/or concepts of science, to longer-term aims for science education.

creation. This paper will present findings from the two phases of review and survey, to explain the conceptualisation and development of the Purposes Framework.

Phase 1: scoping literature review methodology to build a theoretical frame

For the scoping review, we considered both international academic literature and UK-specific grey literature, such as national reports and curricula guidance to ascertain how practical work is described in relation to primary science. We used ERIC, Education Research Complete and Research Search Premier through the institution of the first two authors. We also used Google Scholar to both validate the searches undertaken through the above databases, and to locate articles that may have been missed. For the Google Scholar, we searched by "most relevant", and limited our search to the first 200 articles. Example search terms included "primary", "science education", and "practical work". Relevant grey literature published since 2013 was also included. Where appropriate, seminal academic and grey literature published before 2013 (e.g. Abrahams and Millar 2008) were included. Finally, we also directly searched key journals in science education (e.g. International Journal of Science Education; for full details regarding our scoping review process, see Appendix 2 in Earle et al. 2025).

We followed accepted systematic review procedures for educational research (Page et al. 2021; Zawacki-Richter et al. 2020). Our decision to conduct a scoping review using a systematic approach was to allow for the necessary flexibility on search terms, due to the lack of consistently accepted terminology. This meant that we were restricted in our ability to locate and review all relevant papers in this area. For instance, "inquiry" or "enquiry" pedagogy often includes practical work, but this was implicit rather than providing an explicit discussion of the practical work involved. Our inclusion and exclusion criteria were the following:

> **Inclusion criteria**: included papers were published between 2013 until May 2023; written in English; a full text was available for review; and the content was relevant to practical work in primary science (focused on classroom practice). We included papers presenting empirical work with primary-aged children, as well as articles discussing primary science teaching. Papers describing practical science with secondary students were also included if there were clear implications for practical work in primary science.

> **Exclusion criteria**: papers were excluded if they described contexts outside of primary school science (e.g. informal learning, science in museums etc.); referred to studies of pre-service teacher practice; or the study referred to science teaching only in general terms. (e.g. papers describing a particular science project, or problem-solving teaching approaches without any explicit mention of practical work/'hands-on' approaches within primary science, and so, could be interpreted as non-practical inquiry)

Our systematic process initially returned a total of 1839 sources from academic and grey literature. Each of these papers underwent an abstract screening, whereby the title and abstract of each were independently read by at least two authors in accordance with the inclusion and exclusion criteria, to ascertain whether a review of the full text was required. This screening resulted in the full texts of 195 papers being read, again by at least two authors. Of these, 120 were selected for further discussion between the authors to establish whether the respective papers would be included in our final analysis. This collaborative discussion resulted in an eventual dataset of 54 articles. The 54 included documents were then manually coded by the authors in relation to the research focus, in which we identified practical work definitions, purposes and empirical outcomes. The findings related to purposes are presented below. Purposes from across the included grey and academic literature were grouped by similarity to create inductive categories, resulting in a list of ten possible purposes that formed the theoretical framework for the study. These ten purposes were then applied to the reality of educators' experiences through a UK-wide survey (Phase 2).

Experience of scientific phenomena

A widely held view of the purpose of practical work is that it provides an authentic experience of science (Pun and Cheung 2021, 273), for the individual to experience phenomena themselves, "an *experience for which there is no substitute*" (Osborne 2015, 16). Direct sensory experience features in each of the UK's national curricula (Curriculum for Wales 2019; DfE 2013; Education Scotland 2009; Northern Ireland Curriculum 2007). Children learn directly about the world around them in firsthand essential experiences (PCAG 2023). This purpose goes beyond passive observation, merely being present in the room when a phenomenon is demonstrated, authors argue that direct interaction is important for "*hands-on minds-on exploratory engagement*" (Stylianidou 2014, 6). Such "*embodied learning encourages meaningful sensory and movement experiences*" (Manches and Mitchell 2023, 23). The physical action on objects is important for early learning (Harlen 2014, 5), with concrete experience the starting place of scientific observation, to help children to actively make sense of the world (Earle 2022, 6). Sensory meaning-making helps to build foundational distinctions: "*touch allows us to construct our experiences with natural objects and phenomena, for example, in terms of hot/cold, hard/soft, push/pull, heavy/light, dry/wet and watery/slimy/sticky*" (Tang et al. 2022, 194).

Engagement with "authentic contexts" enables the exploration of phenomena and the raising of questions that can be investigated (Tytler et al. 2021, 1942). Abrahams and Millar (2008, 1948) describe the purpose of practical work as connecting the domain of objects and observables in the real world with the domain of ideas in the abstract world of thinking. Thus, exploratory play and sensory experiences support children's scientific thinking (Johnston 2013), enabling "phenomenon-based reasoning" (Park, Abrahams, and Song 2016, 2537) and linking between subject content and the physical world (SCORE 2013).

Engagement and motivation

To motivate and engage is one of Gatsby's (2017) highly cited five purposes of practical work. Pereira, Rodrigues, and Vieira (2019) proposes affective engagement as one of her three purposes, alongside conceptual development and practical skills (67). While Bangoy (2022, 100) considers engagement to be a main purpose of practical work, using it "*to generate interest and enthusiasm . . . to aid students in remembering things*". Langley (2014, 64) proposes that through the intrigue of carrying out practical science, where the answer is not known, such "*hearts and minds-on*" activities lead to more active engagement and learning.

Hands-on practical science is repeatedly described as leading to raised engagement and positive attitudes towards science (Dunlop et al. 2013; Royal Society 2014; Todas and Skoumios 2014). However, Walan and McEwen (2017, 411) note that children may lose interest if they do not know the purpose of the practical work or if they cannot relate to the context.

Children leading learning

This purpose considers practical work more from the perspective of the child. In curricula documents, children's curiosity is described as a starting point (Curriculum for Wales 2019) and as a means to stimulate question-raising for children to develop their own lines of inquiry (DfE 2013). Practical work has been described as a child-centred approach (Pereira, Rodrigues, and Vieira 2019), with the value of play and exploration in "*generating ideas and questions and fostering a feel for phenomena*" (Stylianidou et al. 2018, 7). Shared, meaningful, physical experiences, with children putting forward their own questions and ideas can support the development of problem solving and agency (Roberts and Reading 2015, 3). This "*student-centred approach to learning*" (Langley 2014) is afforded by practical work where there is the opportunity for open exploration.

Understanding of scientific methods

Teaching the principles of scientific inquiry (Gatsby 2017) emerged as a key purpose for practical work. Such "*enquiry processes develop students" understanding of the scientific approach to enquiry*' (Millar and Abrahams 2009, 61). This purpose includes the knowledge of methods that scientists use to answer questions (Ofsted 2023) and an understanding of the process of planning, doing and reviewing an inquiry.

Authors are keen to emphasise that the knowledge of enquiry processes is not only theoretical, these practices need to be experienced. For Hodson, the "doing" of science was more than practising isolated skills or learning about inquiry principles, it was "*engaging in and developing expertise in scientific inquiry and problem-solving*" (Hodson 2014, 2537). Sometimes the doing of science "*using the practices involved in scientific inquiry*" is termed "*inquiry-based practical work*" (Akuma and Callaghan 2019, 621), however, this is not quite the same as the pedagogical approach of "inquiry-based learning". The latter is an approach that can be used in different subject areas and is very much about giving ownership of the learning direction to the children. This may happen in some scientific inquiries, but a scientific inquiry can be more structured and still provide the experience of "doing" science. Pun and Cheung (2021, 273) note the importance of going beyond simply following procedures, to studying "*real-life problems*".

Development of scientific skills

The development of scientific skills is detailed in curricula (Education Scotland 2009, 2017) and other grey literature. This includes the "*handling equipment and materials safely*" (SCORE 2013, 1) as well as the "*skills associated with observation, measurement and the accurate recording of data*" (Kennedy 2014, 287). A variety of language is utilised when describing scientific skills, for example, "practical skills" (Gatsby 2017), "manipulative skills"

(Langley 2014), "process skills" (Todas and Skoumios 2014), "procedural learning" (Lucas and Hanson 2021), "practices" (NGSS 2013), and as part of "disciplinary knowledge" (Ofsted 2023). Each term has a slightly different emphasis, but an overarching theme is that these involve interaction with real events and often physical manipulation; they are "hands on" (Fotou and Abrahams 2015).

The development of process skills may be an explicit aim of the lesson, where procedures are practised (Millar and Abrahams 2009, 61) and explicitly taught (Luxton and Pritchard 2023, 4), perhaps in a teacher-led "recipe-type" manner (Akuma and Callaghan 2019, 621). Alternatively, the development of procedural knowledge may be more implicit, an unintentional addition to the learning, but one that "*can only be acquired by practice*" (Park, Abrahams, and Song 2016, 2528).

Nature of science

One purpose of practical work that is often implicit is learning "about science" as a discipline, the "nature of science" as an empirical endeavour and dynamic process to explain natural phenomena and generate new knowledge (Needham 2014; Royal Society 2014; Vinko, Delaney, and Devetak 2020). For young children, this may be couched in terms of "*developing behaviours and skills that reflect those of real scientists*" (CCEA 2019, 4), to support them to become "*ethically informed citizens … [who can] evaluate scientific claims to help make informed decisions that affect our environment and well-being*" (Curriculum for Wales 2019, n.p.). This means that practical work can be used to develop understanding of the bigger picture, to understand how scientific knowledge is developed, supporting "*scientific literacy … contributing to the formation of better-informed individuals, and able to apply critical thinking*" (Oliveira and Bonito 2023, 18). "Learning about science", to develop understanding of how the scientific community establishes knowledge (Hodson 2014), is a long-term goal, building "science capital" over time so that children develop the belief that science is "for them", something that they can take part in and/or access (Nag Chowdhuri, King, and Archer 2022).

Use and development of scientific vocabulary

Use of scientific vocabulary could be considered to be part of the development of conceptual understanding (below), but the literature also emphasises the importance of language learning and communication for this age-group, so for this categorisation, it is considered separately. Dialogue and collaboration are an integral part of the classroom, "*enabling children to externalise, share and develop their thinking*" (Stylianidou et al. 2018, 3). Practical work can facilitate "*socialization and acquisition of scientific language*" (Smrečnik, Fošnarič, and Čagran 2014, 254) because it provides rich opportunities for language learning, "*engagement in practices is language intensive*" (NGSS 2013, 3).

The national curricula documentation promotes a move through the primary school years from using everyday language to accurate use of scientific language (Education Scotland 2009; Northern Ireland Curriculum 2007). Guidance for England includes an objective to support children to "*communicate their ideas to a range of audiences in a variety of ways*" (DfE 2013). Multimodal communication and embodied learning theorists propose that children can: "*communicate in ways beyond words, especially gestures*"

(Manches and Mitchell 2023, 23). Practical work can also be seen as inclusive, because "*physical manipulatives are less demanding on language proficiency, they provide a level of access to language learners who are learning science and the language of instruction at the same time*" (Tang et al. 2022, 182). Thus, there is pedagogical value in practical work that goes beyond the learning of science.

Development of conceptual understanding

The overarching aim of practical work for many authors is to support learning about scientific concepts (Needham 2014), underpin understanding (Royal Society 2014) and improve understanding of theory (Gatsby 2017). To enable "thinking back and forth" (Spaan et al. 2022) between the "domain of observables" and the "domain of ideas" (Abrahams and Millar 2008), practical activities are seen as the "*avenue for the development of specific knowledge and understanding of science*" (Omilani et al. 2018, 760). But Hodson (2014, 2537), among others, notes that such practical work needs to be carefully designed to enable the development of conceptual and theoretical knowledge, which he simply terms as "learning science". Such "minds-on" practical work, primarily aimed at the development of scientific ideas (Fotou and Abrahams 2015), can be called "illustrative", designed to show a particular scientific phenomenon in order to support conceptual understanding (Roberts and Reading 2015).

The English National Curriculum mandates that "*[w]orking scientifically" . . . must always be taught through and clearly related to the teaching of substantive science content in the programme of study*' (DfE 2013, 5), in an attempt to link practical work to scientific conceptual understanding, although it is suggesting that "working scientifically" procedural knowledge is also to be taught at the same time. Abrahams and Millar (2008; 1965) argue that "*practical work in science could be significantly improved if teachers recognized that explanatory ideas do not 'emerge' from observations . . . ideas have to be introduced*". Both quotes in the last two sentences hint at a tension between different purposes of practical work, how to move beyond the practical "hands-on" experience to deeper understanding of science concepts and whether to be also trying to develop procedural knowledge at the same time. The lack of a clear focus is perhaps why practical work draws much criticism, especially with all the other possible purposes described in this paper also at play. But without the sensory experience linking the phenomena to the real world, young children may find it more difficult to build abstract scientific knowledge (NGSS 2013; PCAG 2023).

Development of personal and social skills

The final of Gatsby's (2017) purposes is to develop higher-level skills and attributes. These include opportunities to develop skills related to cooperation (Todas and Skoumios 2014, 38), thinking skills (Hanley et al. 2020) and personal capabilities (CCEA 2019, 12). This links to the nature of science, with the Berkeley framework (2008, 6) describing the importance of scientists working together and sharing ideas with each other. Others draw attention to foundational spatial skills developed during interaction with practical three-dimensional objects (Tang et al. 2022, 191). In relation to social skills, Pereira, Rodrigues, and Vieira (2019, 66) note that practical work provides an opportunity for practitioners to build rapport with the children, with playful exploration being a more open activity that can lead to novel communication.

Relating to their own world and cross-curricula context

This purpose encompasses both real-world contexts (Bianchi, Whittaker, and Poole 2021; Luxton and Pritchard 2023), together with relating experiences to personal contexts, moving from an experience of the phenomena, to the individual. Relevance is a key feature within this purpose (Royal Society 2014, 47), studying "*real-life problems*" goes beyond following procedures to application (Pun and Cheung 2021, 274). The PCAG group (PCAG, 9) propose that such experiences "*provide an equitable basis for learning*".

Authors also emphasise the cross-curricular nature of primary schools, where there are fruitful connections to be made between subjects. For example, Tytler et al. (2021; 1942) explore the "mutually reinforcing" disciplines of science and mathematics, where "*developing ideas in one subject leads to questions that drive and inform learning in the other*". Three of the UK nations embed cross-curricular ideals: STEM and interdisciplinary links in Scotland (Education Scotland 2017), Science and Technology Area of Learning in Wales (Curriculum for Wales 2019) and in the World Around Us in Northern Ireland (CCEA 2022).

The ten possible purposes of practical science gathered from the literature above provide a comprehensive list for why educators may choose to use practical work in their science lessons. It is acknowledged that the collated list of ten is not the only way these purposes could be organised, but they provide a starting point for exploration with teachers, as we ask them whether the theory described in the literature matches their reality.

Phase 2: survey methodology

Survey design

For this research, we created an online survey that was disseminated to primary science educators across the UK (e.g. teachers, science leads and teacher educators), via regional and national primary science education networks, and using social media. The focus of this survey was to explore primary science educators' understanding regarding the purpose of practical work in primary science across the UK. The survey began by asking participants to describe their professional role. Participants were then asked to qualitatively describe what they thought the purpose of practical work within primary science was. Continuing on with the survey, participants were given the list of ten possible reasons for conducting primary science practical work with children. These statements are shown on Table 1, and originated from the analysis above. After reading these statements, participants were first asked to rate the importance ("not very important", "somewhat important" or "most important") for children's learning. Participants were able to rate more than one statement as "most important" due to the challenges in ranking perceived importance of each statement. Participants were then asked to read the statements again and rate the likelihood of these ("not likely", "somewhat likely", "very likely") being reasons why educators use practical work in a primary classroom.

Table 1. Ten Statements describing possible reasons for doing practical work with children in primary science.

Statement Number	Statement
1	**Experience** scientific phenomena (e.g. real world sensory interactions)
2	Be **engaged** and motivated (e.g. children being interested in learning and doing science)
3	**Lead** their own learning (e.g. asking questions and making decisions)
4	Develop understanding of the **scientific enquiry methods** (e.g. plan, do, review)
5	Develop **scientific skills** (e.g. observing, gathering and measuring data scientifically using equipment)
6	Develop understanding of what it means to do science and **be a scientist**
7	Learn and use scientific **vocabulary**
8	Develop **conceptual understanding** (e.g. deepen and apply scientific knowledge)
9	Develop personal and **social skills** (e.g. oracy, collaboration, perseverance)
10	Relate science learning to their **own world and cross-curricula** context
	Any other reason not listed above

The titles of the ten purposes were written in everyday language with examples so that academic terminology was not a barrier to the educators completing the survey. For example, "nature of science" is a commonplace term in the literature, but is not commonly used by the UK teaching profession, so this has been phrased briefly as "develop understanding of what it means to do science and be a scientist" in purpose 6 below. After completing their quantitative rankings, participants were invited to qualitatively describe their reasoning. Participants were finally invited to qualitatively share any anonymous example of effective primary science practical work.

Data analysis

Quantitative data was analysed using descriptive statistics. Qualitative data was analysed using thematic analysis in accordance with the ten statements described in Table 1. For this thematic analysis, we followed the six-step process described by Braun and Clarke (2006). Specifically, each survey response was read, and where participants had described the purpose of practical work in primary science and/or an example, codes of interest, and eventual themes, were created that mapped onto, or challenged, one or more of the statements in Table 1. Constructed codes and themes were revised as necessary as part of the authors' discussions about data analysis.

Participants

In total, 231 educators completed the survey. The majority of the participants were based in England although all four nations were represented in similar proportions to population size, and were primary-school teachers with responsibility for leading science, who were currently teaching and who had more than ten years teaching service. For detailed information regarding the region and role(s) of the participants, their length and recency of their teaching experience, and their level of formal science education, see (Earle et al. 2025, Appendix 3).

Phase 2: survey findings

The findings are presented according to two headings: (i) the purpose of practical work in primary science education; and (ii) the importance and likelihood of reasons for doing practical work

Purpose of practical work in primary science education

Participants provided an array of perspectives when describing what they considered to be the purpose of practical work in primary science (in response to an open question before they saw the provided list of ten). Each of the ten statements were evidenced across the dataset. In many cases, participants' definitions of practical mapped onto more than one statement. Examples are provided below as examples to demonstrate how the ten purposes were enacted in participant responses.

Statement 1 (experience)

> Participant from England (50): To give children experiences within the context of real life problem solving and understanding the world around us through asking questions.

Regarding experiencing real-world phenomena, participants commonly referred to practical work providing children with an opportunity to sense and understand the world around them (e.g. through sight, smell, touch, etc.), as in the example provided above. In doing so, the practical work provides children with experiences that helps concretise theories and abstract ideas.

Statement 2 (engagement)

> Participant from England (91): . . . They need to be doing practical science to develop their curiosity and sense of wonder using all their senses.

Practical work was often seen as a means of encouraging children's engagement and motivation. Participants shared examples of wanting to inspire children to develop an "enjoyment" and "love" for science, as well as a "curiosity" and "sense of wonder" about the discipline, as noted in the quote above. Participants also discussed the importance of practical work in shaping transition experiences/careers within STEM subjects.

Statement 3 (children leading)

> Participant from Wales (4): It is also used to develop their problem solving skills, by giving them opportunities to lead their own learning and plan their own investigations from scratch when they are given a goal to achieve.

Participants shared how practical work gave children the opportunity to lead their own learning, as evidenced by references to "thinking", "questioning", "asking questions", "decision making," etc. Children being provided with opportunities to lead their own learning was attributed by some participants as helping to improve children's knowledge of the topic they are investigating.

Statement 4 (scientific methods)

> Participant from Scotland (14): … Hands-on activities allow students to practice important skills like observation, measurement, prediction, experimentation, and drawing conclusions. These skills form the foundation for future scientific learning. … Through practicals, students learn about important science processes like fair testing, controlling variables, modelling, etc. This develops their understanding of the scientific method.

Participants shared a recognition of the importance of understanding the methods of doing science, which could include a list of science skills (statement 5 below), as well as types of enquiry, as noted above. Participants sought to allow children to "become familiar with the processes of scientific enquiry" (participant from England 49) in various ways, such as planning the practical work, "record data, interpret data, draw conclusions and evaluate the practical work" (participant from England 81).

Statement 5 (scientific skills)

> Participant from England (101): … To practise scientific skills such as observing and measuring, setting up tests, collecting sufficient data to be able to draw conclusions. To give opportunity to develop skills of using and naming pieces of scientific equipment.

Extending statement 4, participants highlighted the importance of children learning the skills associated with practical science in a "hands-on" fashion. Participants raised the importance of using scientific skills "to embed the concepts that they are being taught in order to deepen their knowledge and understanding" (participant from England 97), through activities such as measuring, creating experiments and naming science apparatus.

Statement 6 (meaning of being a scientist)

> Participant from England (26): … Most scientists are engaged in practical activity, if not personally then as part of a research community; by doing practical activity children experience some aspects of what it is like to work like a scientist and get a feel for that way of life.

Primary school children developing an understanding of what it means to do science and be a scientist was also raised as a purpose of practical work. Participants described the importance of children seeing themselves as scientists when experiencing practical work, with some participants expressing a hope that this exposure may encourage children to imagine future careers in science.

Statement 7 (vocabulary)

> Participant from England (88): … and provide an engaging opportunity to be introduced to, experience and use scientific language/vocabulary.

A minority of participants described the purpose of practical work as helping to shape children's exposure to, and use of, scientific language and vocabulary. Examples were provided by participants describing how a shared scientific language and vocabulary helped children when working collaboratively, and in understanding the world around them.

Statement 8 (conceptual understanding)

> Participant from England (82): Practical work allows children to think and consider the concepts and apply their understanding. It is not about teachers telling children scientific concepts, the children need to engage with the knowledge in a practical way to think about it and understand it. When taught well[,] practical work allows children to be creative and critical thinkers to have ideas and know how to investigate. Engaging in practical work within science allows children to think scientifically ...

Practical work as a means of developing children's conceptual, theoretical understanding of scientific topics was discussed. Participants described the importance of giving primary school children substantive exposure to relevant scientific concepts. As the quote above exemplifies, participants stressed the importance of children learning and experiencing scientific concepts for themselves. To provide sensory experiences of materials and phenomena to help build foundational concepts that will be developed further in their future studies of Biology, Chemistry and Physics.

Statement 9 (social skills)

> Participant from Northern Ireland (6): Practical work allows children to develop their social skills by having to work collaboratively with their peers, learning how to work well as part of a pair or team, take turns and solve conflict.

Participants commonly raised how they thought a purpose of practical work was to develop children's personal and social skills, or "soft skills" that would not necessarily be taught within science curricula. Examples of personal and social skills reported by participants were numerous, including, but not limited to: learning to work both independently and collaboratively, including managing the discussion and shared understanding and empathy that comes from collaboration; ability to problem solve, including the development of logic and reasoning; develop "perseverance, tenacity, diligence, resilience, self reliance" (participant from England 61); gaining confidence in science; and developing gross and fine motor skills.

Statement 10 (own world and cross-curricula)

> Participant from England (112): It lays the foundation for future scientific endeavors and helps children develop skills that extend beyond the realm of science into various aspects of their education and personal growth.

Finally, participants shared how they felt a purpose of practical work was to relate science learning to their own world and cross-curricula context. Examples of this statement were evidenced with participants reporting how practical work should be relevant and relatable for children, so that they can apply scientific ideas to their everyday lives and help them understand the world around them. Cross-curricula examples were also provided, with some participants stressing how practical science should provide children the necessary tools to apply their understanding to other subjects.

Importance versus likelihood of reasons for doing practical work in primary science education

As shown in Table 2 and Figures 2 and 3 below, participants demonstrated an awareness of the importance of particular reasons for conducting practical primary science work as well as the perceived likelihood of these reasons being determinants for enacted practical science work in the classroom. Specifically, the perceived importance of the reasons for doing practical work was consistently rated more highly than the perceived likelihood. For instance, a considerable majority of participants felt that statement 1: "experience scientific phenomena" was most important, but a comparatively smaller proportion of the sample felt that this statement was a very likely reason for why primary science teachers use practical work in their classroom.

Whilst there are small variations in the allocation of importance, the overwhelming response from participants is one of "everything is important" (Figure 2). With primary school teachers in the UK largely being responsible for all of the lessons in their class, it is perhaps understandable that all possible purposes are deemed important. As seen in the literature, practical work in primary science can fulfill many purposes, but the

Table 2. Participants' ratings regarding to what extent the ten statements of Table 1 are important and/or likely, respectively.

	Number: $N = 231$(%)							
	Importance				Likelihood			
Statement	Not Very Important	Somewhat Important	Most Important	Missing	Not Likely	Somewhat Likely	Very Likely	Missing
1 (Experience)	1 (<0.01)	67 (29.0)	162 (70.1)	1 (<0.01)	24 (10.4)	95 (41.1)	110 (47.6)	2 (0.01)
2 (Engaged)	2 (0.01)	31 (13.4)	197 (85.3)	1 (<0.01)	15 (6.5)	44 (19.0)	170 (73.6)	2 (0.01)
3 (Lead)	5 (2.2)	73 (31.6)	152 (65.8)	1 (<0.01)	56 (24.2)	121 (53.4)	51 (22.1)	3 (1.3)
4 (Scientific enquiry methods)	5 (2.2)	92 (39.8)	132 (57.1)	2 (0.01)	20 (8.7)	102 (44.2)	106 (45.9)	3 (1.3)
5 (Scientific skills)	1 (<0.01)	52 (22.5)	176 (76.2)	2 (0.01)	10 (4.3)	74 (32.0)	145 (63.8)	2 (0.01)
6 (be a scientist)	5 (2.2)	106 (45.9)	119 (51.5)	1 (<0.01)	64 (27.7)	112 (48.5)	52 (22.5)	3 (1.3)
7 (vocabulary)	5 (2.2)	111 (48.1)	112 (48.5)	3 (1.3)	23 (10.0)	101 (43.7)	103 (44.6)	4 (1.7)
8 (conceptual understanding)	1 (<0.01)	87 (37.7)	142 (61.5)	1 (<0.01)	30 (13.0)	112 (48.5)	86 (37.2)	3 (1.3)
9 (social skills)	6 (2.6)	100 (43.3)	124 (53.7)	1 (<0.01)	48 (20.8)	113 (48.9)	67 (29.0)	3 (1.3)
10 (own world and cross curricula)	3 (1.3)	74 (32.0)	152 (65.8)	2 (0.01)	43 (18.6)	119 (51.5)	66 (28.6)	3 (1.3)
Other	2 (0.01)	3 (1.3)	10 (4.3)		2 (0.01)	3 (1.3)	7 (3.0)	

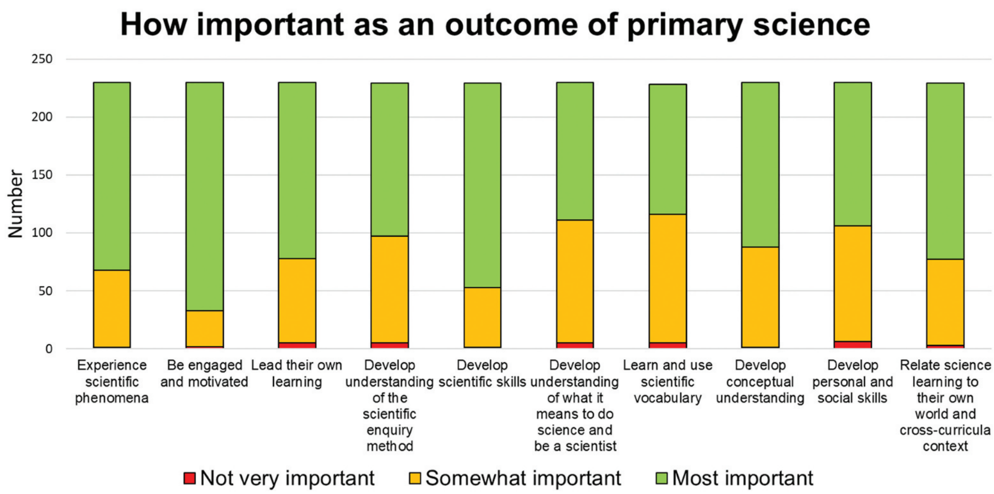

Figure 2. How important each purpose is perceived to be.

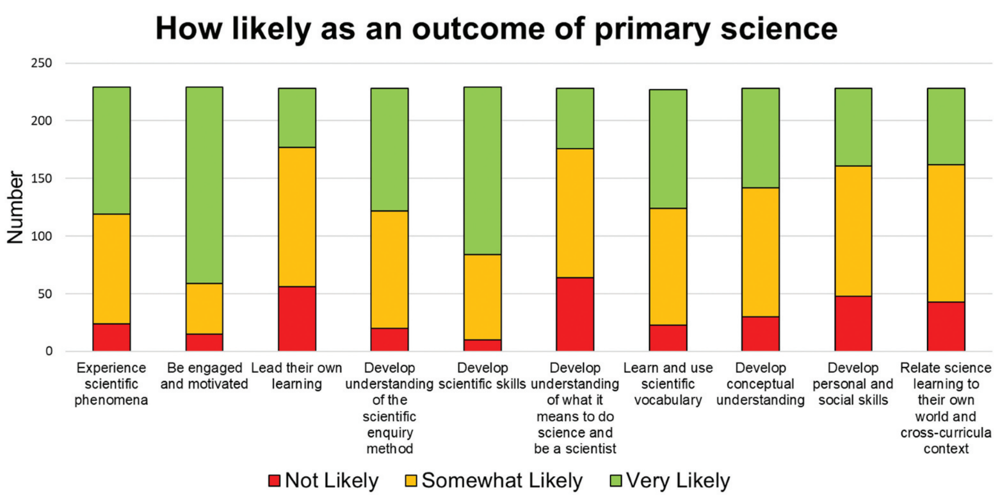

Figure 3. How likely each purpose is perceived to be.

question remains as to whether educators should be trying to accomplish all of these with the same practical activity. The slightly more negative response demonstrated for likelihood of purposes to be enacted in the classroom (Figure 3), points to the challenges of carrying out practical work to support children to lead their own learning or develop an understanding of the nature of science. A limitation of the survey was that it was not possible to explore these issues more directly with teachers, but in a follow up Phase 3 of the project involving teacher interviews, they described barriers such as subject status, resourcing, confidence and pedagogical content knowledge (Earle et al. 2025). This work with teachers is ongoing, as we seek to exemplify practical work in action, but in the meantime, we return to our focus on purposes for this paper.

Discussion

All ten of the purposes collated from the literature were evident within the survey data. This points to the recognition that practical work in primary science is valued for a wide range of reasons. With the majority of educators also noting the importance of each possible purpose, the assertion that practical work in primary science is an important feature of practice is supported. However, with a myriad of possible purposes and some deemed “less likely” to happen in practice, the question of manageability is raised. It is proposed that clarity regarding what to prioritise could help educators to make practical work more purposeful. Thus we put forward a “Purposes Framework” (Figure 1) to help educators consider, select and prioritise a particular focus for each practical activity.

The motivation and engagement associated with experiencing practical work (statements 1 and 2) is well documented within the literature (e.g. Gatsby 2017; PCAG 2023; Stylianidou 2014; Tang et al. 2022) and scored highly in terms of importance and likelihood in the educator survey. We propose that this is a gateway purpose, a mechanism for engaging the children with the science learning experience, as denoted by it being at the top of the Framework (Figure 1). Once this curiosity and attention has been captured, the core purpose of the practical activity within the lesson can be to develop the practices and/or the concepts of science. The “practices” draws together the disciplinary knowledge and skills of science (statements 1, 4 and 5, e.g. Gatsby 2017; Hodson 2014; Park, Abrahams, and Song 2016), whilst the content of science (Biology, Chemistry and Physics) is drawn together under the concepts of science (statements 1, 7 and 8, e.g. Abrahams and Millar 2008; Luxton and Pritchard 2023; Spaan et al. 2022). We argue that these are the core purposes for primary teachers to utilise practical work. These are “lesson-level” objectives that can support the evaluation of the activity, to consider whether the practical work has supported the children’s learning of a particular science practice or concept.

The experience of scientific phenomena (statement 1) supports engagement, practices and concept development, with “experience” being explicit in the definition presented above, as an essential part of what makes an activity “practical”. In addition to “practices” and “concepts”, the other purposes are longer-term, things that will build over time to support science identity, capital and understanding of the nature of science (statements 6 and 10, e.g. CCEA 2019; Nag Chowdhuri, King, and Archer 2022; Oliveira and Bonito 2023). In addition, with primary school teachers being responsible for children’s learning across the curriculum, they are best placed to make links with other subject areas and competencies, for example, applying mathematical learning or developing independence, thinking and social skills (statements 3, 9 and 10, e.g. Hanley et al. 2020; Pereira, Rodrigues, and Vieira 2019; Tytler et al. 2021). Thus the Purposes Framework presents a new prioritisation for practical work in primary science, with engagement as the gateway to capture attention, with the focus being the core learning of science practices and/or concepts, and the other purposes being built up over time.

Link to Figure 1: Purposes of Practical Work in Primary Science Framework.

Limitations

The Purposes Framework is presented as a structure to support discussion in the field, but merits further research to explore whether it is useful as a tool for practitioners in the UK and beyond. By utilising non-curriculum-specific wording (e.g. not using the phrase of "Working scientifically" that denotes disciplinary knowledge in curriculum guidance for England), it may not be specific enough for each context and require further exemplification. The project is ongoing and we aim to delve further into current practice via in-depth interviews and school visits, to allow exploration of the enactment of purposeful practical work.

While the survey respondents were broadly representative of the primary science education profession across the four nations of the UK, we recognise that participants may reflect professionals with a particular interest, expertise or experience in primary science. This means that our findings cannot be considered reflective of the primary education sector as a whole. Further research that delves into the experiences of a wider cohort of primary educators may be beneficial.

Conclusion

The aim of this study was to develop a better understanding of purposeful practical work in primary school science. We found that there are a wide range of potential purposes within both the literature and educator viewpoints in the UK. We offer the Purposes Framework as a means for making more focused decisions regarding practical work, allowing judgements of effectiveness. In addition, attention is also directed to the definition of practical work presented at the outset, which by embedding the need to link both "hands-on" and "minds-on" (Abrahams and Millar 2008) within the definition, we point practitioners towards the core purposes of developing practices and concepts in science learning.

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Notes on contributors

Sarah Earle is Professor of Primary Science Education at Bath Spa University, leading projects on practical work and teacher assessment in primary science.

Stuart Read is Reader in Disability Studies and Inclusion Research, working on projects such as 'We Are The People' at Bath Spa University.

Lynne Bianchi is Professor at The University of Manchester, with the roles of both Director of Science & Engineering Education Research and Innovation Hub and Vice Dean for Social Responsibility, Equality, Diversity, Inclusion and Accessibility.

Julie Jordan is a Visiting Researcher at the Science & Engineering Education Research and Innovation Hub (SEERIH) at The University of Manchester.

ORCID

Sarah Earle http://orcid.org/0000-0002-6155-1098
Stuart Read http://orcid.org/0000-0003-2380-4936
Lynne Bianchi http://orcid.org/0000-0001-9605-6452

Ethical approval statement

Ethical approval for this research was granted by the School of Education Ethics Panel, Bath Spa University (230223SE).

References

Abrahams, I., and R. Millar. 2008. “Does Practical Work Really Work? A Study of the Effectiveness of Practical Work as a Teaching and Learning Method in School Science.” *International Journal of Science Education* 30 (14): 1945–1969. https://doi.org/10.1080/09500690701749305.

Abrahams, I., M. J. Reiss, and R. Sharpe 2014. “The Impact of the ‘Getting Practical: Improving Practical Work in Science’ Continuing Professional Development Programme on teachers’ Ideas and Practice in Science Practical Work.” *Research in Science & Technological Education* 32 (3): 263–280. https://doi.org/10.1080/02635143.2014.931841.

Akuma, F. V., and R. Callaghan. 2019. “A Systematic Review Characterizing and Clarifying Intrinsic Teaching Challenges Linked to Inquiry-Based Practical Work.” *Journal of Research in Science Teaching* 56 (5): 619–648.

Bangoy, R. M. 2022. “Practical Work Approach: A Tool to Improve the Creativity Skills of the Students in Recycling. GLOBUS.” *Journal of Progressive Education* 12 (1): 100–103.

Berkeley. 2008. *Science Conceptual Framework*. California, US: University of Berkeley. https://undsci.berkeley.edu/for-educators/prepare-and-plan/conceptual-framework/.

Bianchi, L., C. Whittaker, and A. Poole. 2021. *The 10 Key Issues with Children’s Learning in Primary Science in England*. Manchester, UK: The University of Manchester & The Ogden Trust.

Braun, V., and V. Clarke. 2006. “Using Thematic Analysis in Psychology.” *Qualitative Research in Psychology* 3 (2): 77–101. https://doi.org/10.1191/1478088706qp063oa.

CCEA (Council for the Curriculum Examinations and Assessment). 2019. *Science and Technology Within the World Around Us: Progression Guidance*. Belfast, Northern Ireland: CCEA.

CCEA (Council for the Curriculum Examinations and Assessment). 2022. *Science and Technology Progression Pathway*. Belfast, Northern Ireland: CCEA.

Curriculum for Wales. 2019. “Curriculum for Wales: Science and Technology.” https://hwb.gov.wales/curriculum-for-wales/science-and-technology/ .

DfE (Department for Education). 2013. “Science Programmes of Study: Key Stages 1 and 2 National Curriculum in England.” https://assets.publishing.service.gov.uk/media/5a806ebd40f0b62305b8b1fa/PRIMARY_national_curriculum_-_Science.pdf .

Dunlop, L., K. Compton, L. Clarke, and V. McKelvey-Martin. 2013. “Child-Led Enquiry in Primary Science.” *Education 3-13* 43 (5): 462–481. https://doi.org/10.1080/03004279.2013.822013.

Earle, S. 2022. “Research Review: Early Science Research Summary - Use of Play and Role of the Adult.” *Journal of Emergent Science* 22:5–12. https://www.ase.org.uk/resources/journal-of-emergent-science/issue-22/research-review-early-science-research-summary-use-of.

Earle, S., S. Read, L. Bianchi, and J. Jordan. 2025. *Purposeful Practical Work in Primary Science*. Bath, UK: Bath Spa University & The University of Manchester. https://www.bathspa.ac.uk/projects/practical-work-in-primary-school-science/ .

Education Scotland. 2009. *Curriculum for Excellence: Sciences Experiences and Outcomes*. Edinburgh, Scotland: Education Scotland. https://education.gov.scot/media/jcxpmwd5/sciences-eo.pdf.

Education Scotland. 2017. *Benchmarks: Sciences*. Edinburgh, Scotland: Education Scotland.

Fotou, N., and I. Abrahams. 2015. "Doing with Ideas: The Role of Talk in Effective Practical Work in Science." *The School Science Review* 97 (359): 25–30.

Gatsby. 2017. *Good Practical Science*. The Gatsby Charitable Foundation. https://www.gatsby.org.uk/uploads/education/reports/pdf/good-practical-science-report.pdf .

Hanley, P., H. Wilson, B. Holligan, and L. Elliott. 2020. "Thinking, Doing, Talking Science: The Effect on Attainment and Attitudes of a Professional Development Programme to Provide Cognitively Challenging Primary Science Lessons." *International Journal of Science Education* 42 (15): 2554–2573. https://doi.org/10.1080/09500693.2020.1821931.

Harlen, W. 2014. "Helping Children's Development of Inquiry Skills." *Inquiry in Primary Science* 1:5–19. https://www.platformsamenonderzoeken.nl/wetenwatwerkt/wp-content/uploads/sites/3/2021/06/Helping-childrens-development-of-inquiry-skills-2014.pdf.

Hodson, D. 2014. "Learning Science, Learning About Science, Doing Science: Different Goals Demand Different Learning Methods." *International Journal of Science Education* 36 (15): 2534–2553. https://doi.org/10.1080/09500693.2014.899722.

Johnston, J. 2013. "The Effect of Two Pedagogical Approaches on the Scientific Development of Predictions and Hypothesis in the Early Years." *Journal of Emergent Science* 6:6–11. https://www.ase.org.uk/resources/journal-of-emergent-science/issue-6.

Kennedy, D. 2014. "The Role of Investigations in Promoting Inquiry-Based Science Education in Ireland." *Science Education International* 24 (3): 282–305. https://www.icaseonline.net/sei/september2013/P3.pdf.

Langley, M. 2014. "Supporting Teachers and Technicians in the Delivery of High-Quality, Effective Practical Science." *The School Science Review* 96 (355): 63–69.

Lucas, B., and J. Hanson. 2021. *Reimaging Practical Learning in Secondary Schools: A Review of the Evidence*. London, UK: Royal Academy of Engineering. https://raeng.org.uk/practical-learning.

Luxton, K., and B. Pritchard. 2023. *Improving Primary Science: Guidance Report*. London, UK: Education Endowment Foundation.

Manches, A., and E. Mitchell. 2023. "Embodied Learning for Early and Primary Science: Key Implications from the Move2Learn Project." *Journal of Emergent Science* 24:23–32. https://www.ase.org.uk/resources/journal-of-emergent-science/issue-24/embodied-learning-early-and-primary-science-key.

Markwick, A., and M. J. Reiss. 2023. "Professional Learning in Primary Science: Developing Teacher Confidence to Improve the Leadership of Teaching and Learning." *International Journal of Science Education* 46 (13): 1339–1359. https://doi.org/10.1080/09500693.2023.2288660.

Millar, R., and I. Abrahams. 2009. "Practical Work: Making It More Effective." *The School Science Review* 91 (334): 59–64. http://www.gettingpractical.org.uk/documents/RobinSSR.pdf.

Nag Chowdhuri, M., H. King, and L. Archer. 2022. "The Primary Science Capital Teaching Approach: Building Science Engagement for Social Justice." *Journal of Emergent Science* 23:34–38. https://www.ase.org.uk/resources/journal-of-emergent-science/issue-23/research-review-primary-science-capital-teaching.

Needham, R. 2014. "The Contribution of Practical Work to the Science Curriculum." *The School Science Review* 95 (352): 63–69.

NGSS (Next Generation Science Standards). 2013. *Science and Engineering Practices in the NGSS - Appendix F*. USA: NGSS. https://www.nextgenscience.org/sites/default/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf.

Northern Ireland Curriculum. 2007. *The Northern Ireland Curriculum: Primary*. Council for the Curriculum Examinations and Assessment (CCEA). Belfast, Northern Ireland.

Ofsted. 2023. *Finding the Optimum: The Science Subject Report*. London, UK: Ofsted. https://www.gov.uk/government/publications/subject-report-series-science/finding-the-optimum-the-science-subject-report–2.

Oliveira, H., and J. Bonito. 2023. "Practical Work in Science Education: A Systematic Literature Review." *Frontiers in Education* 8:1151641. https://doi.org/10.3389/feduc.2023.1151641.
Omilani, N. A., S. A. Akinyele, T. S. Durowoju, and E. I. Obideyi. 2018. "The Effect of the Assessment of Practical-Based Work on Pupils' Problem Solving and Achievement in Basic Science and Technology in Odeda Local Government of Ogun State, Nigeria." *Education 3-13* 47 (6): 760–772. https://doi.org/10.1080/03004279.2018.1534874.
Osborne, J. 2015. "Practical Work in Science: Misunderstood and Badly Used?" *The School Science Review* 96 (357): 16–24.
Page, M. J., J. E. McKenzie, P. M. Bossuyt, I. Boutron, T. C. Hoffmann, C. D. Mulrow, L. Shamseer, et al. 2021. "The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews." *The British Medical Journal* 372:71. https://doi.org/10.1136/BMJ.n71.
Park, J., I. Abrahams, and J. Song. 2016. "Unintended Knowledge Learnt in Primary Science Practical Lessons." *International Journal of Science Education* 38 (16): 2528–2549. https://doi.org/10.1080/09500693.2016.1250968.
PCAG (Primary Curriculum Advisory Group). 2023. *Framework for a Future Primary Science Curriculum*. Manchester, UK: PCAG.
Pereira, S., M. J. Rodrigues, and R. M. Vieira. 2019. "Scientific Literacy in the Early Years – Practical Work as a Teaching and Learning Strategy." *Early Child Development & Care* 190 (1): 64–78. https://doi.org/10.1080/03004430.2019.1653553.
Pun, J. K. H., and K. K. C. Cheung. 2021. "Meaning Making in Collaborative Practical Work: A Case Study of Multimodal Challenges in a Year 10 Chemistry Classroom." *Research in Science & Technological Education* 41 (1): 271–288. https://doi.org/10.1080/02635143.2021.1895101.
Roberts, R., and C. Reading. 2015. "The Practical Work Challenge: Incorporating the Explicit Teaching of Evidence in Subject Content." *The School Science Review* 96 (357): 31–39. https://durham-repository.worktribe.com/output/1436127/.
Royal Society. 2014. *Vision for Science and Mathematics Education*. London, UK: The Royal Society.
SCORE (Science Community Representing Education). 2013. *Resourcing Practical Science in Primary Schools*. London, UK: SCORE.
Smrečnik, I. D., S. Fošnarič, and B. Čagran. 2014. "Analysis of the Implementation of Practical Work in the Area of Early Science Education of Primary School Pupils in the Republic of Slovenia." *New Educational Review* 36:235–265. https://cejsh.icm.edu.pl/cejsh/element/bwmeta1.element.ojs-doi-10_15804_tner_14_36_2_20 .
Spaan, W., R. Oostdam, J. Schuitema, and M. Pijls. 2022. "Analysing Teacher Behaviour in Synthesizing Hands-On and Minds-On During Practical Work." *Research in Science & Technological Education* 42 (2): 219–236. https://doi.org/10.1080/02635143.2022.2098265.
Stylianidou, F. 2014. "Creativity in Science and Mathematics Education for Young Children: Executive Summary." http://www.creative-little-scientists.eu/sites/default/files/Creativity_in_Science_and_Mathematics_Education.pdf .
Stylianidou, F., E. Glauert, D. Rossis, A. Compton, T. Cremin, A. Craft, and S. Havu-Nuutinen. 2018. "Fostering Inquiry and Creativity in Early Years STEM Education: Policy Recommendations from the Creative Little Scientists Project." *European Journal of STEM Education* 3 (3): 15. https://doi.org/10.20897/ejsteme/3875.
Tang, K. S., F. Jeppsson, K. Danielsson, and E. Bergh Nestlog. 2022. "Affordances of Physical Objects as a Material Mode of Representation: A Social Semiotics Perspective of Hands-On Meaning-Making." *International Journal of Science Education* 44 (2): 179–200. https://doi.org/10.1080/09500693.2021.2021313.
Todas, A., and M. Skoumios. 2014. "Practical Work in Primary Science: Actions and Verbalized Knowledge." *The International Journal of Early Childhood Learning* 20 (2): 37–50. https://doi.org/10.18848/2327-7939/CGP/v20i02/58951.
Tytler, R., J. Mulligan, V. Prain, P. White, L. Xu, M. Kirk, C. Nielsen, and C. Speldewinde. 2021. "An Interdisciplinary Approach to Primary School Mathematics and Science Learning." *International Journal of Science Education* 43 (12): 1926–1949. https://doi.org/10.1080/09500693.2021.1946727.

Vinko, L., S. Delaney, and I. Devetak. 2020. "Teachers' Opinions About the Effect of Chemistry Demonstrations on Students' Interest and Chemistry Knowledge." *Center for Educational Policy Studies Journal* 10 (2): 9–25.

Walan, S., and B. McEwen. 2017. "Primary Teachers' Reflections on Inquiry- and Context-Based Science Education." *Research in Science Education* 47 (2): 407–426. https://doi.org/10.1007/s11165-015-9507-5.

Wei, B., Z. Jiang, and L. Gai 2022. "Examining the Nature of Practical Work in School Science Textbooks: Coverage of the Diversity of Scientific Methods." *Science & Education* 31: 943–960. https://doi.org/10.1007/s11191-021-00294-z.

Zawacki-Richter, O., M. Kerres, S. Bedenlier, M. Bond, and K. Buntins, eds. 2020. *Systematic Reviews in Educational Research: Methodology, Perspectives and Application*. Wiesbaden, Germany: Springer. https://doi.org/10.1007/978-3-658-27602-7.